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Instrumentation of the Cervical Spine by Fixing Sensors on the Anterior Part of the Vertebra

P. Potier, J. P. Lassau

ABSTRACT

In order to obtain data on the behavior of the cervical spine, sensors were fitted, in boxes, to the anterior parts of three vertebrae (C2,C5,T1). This instrumentation was required for a series of 19 low-speed, rear-end impact tests carried out on 3 unembalmed cadavers. This instrumentation required a fine dissection of the anterior part of the neck, taking care to avoid lesion of the different anatomical structures. The sensors included in the box were 1) one angular velocity sensor Y axis, 2) one linear accelerometer X axis, 3) one linear accelerometer Z axis, and 4) X-ray photographs were used to check the positioning of the sensors before and after fixing the sensor box. The cervical sensor screws were checked manually between the tests. In conclusion, this methodology allowed data to be obtained on each of the three cervical vertebrae instrumented without any damage to the mechanical coupling throughout the tests.

INTRODUCTION AND METHODS

The aim of the instrumentation technique described was to obtain dynamic data on the C2, C5, and T1 vertebra reducing the relative motion between the sensor and the bone during low-speed rear-end impact. The method used to achieve this was to fix the sensors on the anterior face of the vertebra body. It includes the following steps: 1) presentation of the device, 2) dissection of the neck, 3) positioning of the C2 sensor box, 4) positioning of the C5 and T1 sensor boxes, and 5) X-ray check of the final position of sensors.

DESCRIPTION OF DEVICE

Three boxes containing sensors are fixed on C2, C5, and T1. Each box includes two accelerometers and one angular velocity sensor. The accelerometers were positioned to measure along the x- and z-axes. The angular velocity sensor is positioned to measure along the y-axis.

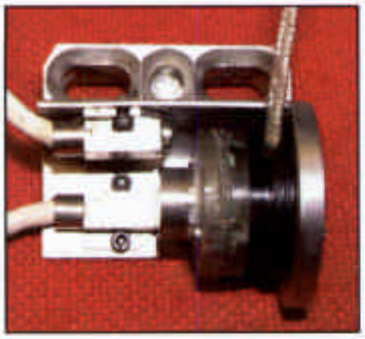

Figure 1. Sensors inside the box

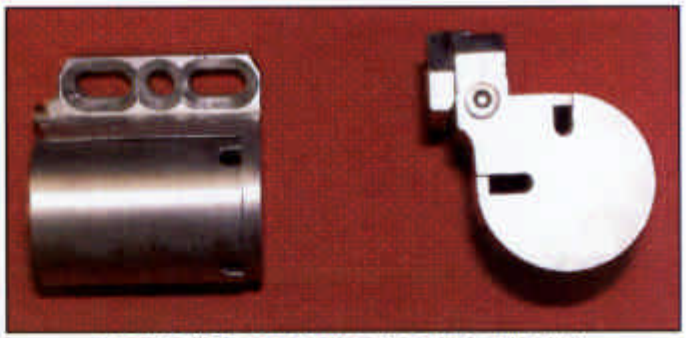

Figure 2. Sensors boxes, front and side view

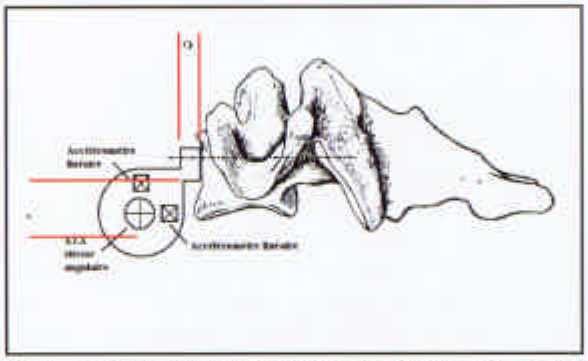

Figure 3. Side view of a vertebra equipped with a sensor box

Since the space inside the oro-pharynx is limited, the box is offset downward with respect to the fixing screws (Figure 3.b). To avoid contact with nearby vertebrae during flexion, the box is offset forward with respect to the mounting plate (Figure 3.a). The boxes have a cylindrical form in order to allow tissue sliding during tests.

DISSECTION OF THE NECK

The aim of the technique is to minimize ligament and muscle lesion. To do this, the following steps are carried out on both sides of the neck. First an incision of the skin and platysma muscles from the sterno-clavicle joint to the temporo-mandibule joint was made. This was followed by the dissection of the anterior edge and deep face of the sternocleidomastoid muscle. The transverse cervical vein was then clamped and the dissection of the omohyoid and sternohyoid muscles and section of the omohyoid muscle was conducted. Similarly, the anterior jugular vein was clamped and dissection of the internal jugular vein was conducted. This was followed by the dissection clamping and section of the internal and external carotid artery as high as possible. At the bottom of the dissected area, clamping and section of the common carotid artery was carried out. Dissection of the anterior face of the cervical spine from C1 to C7 and the upper part of the thoracic spine to T2. By doing this, the anterior face is totally free providing the space necessary to place the sensor boxes.

Figure 5. Anterior face of cervical spine, lower view

Figure 6. Anterior face of cervical spine, upper view

POSITIONING OF THE C2 SENSORS BOX

First of all, the positioning of the C2 sensor box is defined using the finger to find the anterior tubercle on C1. In order to position the screw-driver, the mouth is opened and the posterior wall of the oropharynx is dissected. The C2 sensor box is screwed onto the base of the odontoid process under the anterior tubercle of C1 after an X-ray check on the position and axes.

Figure 7. Screw on the base of the odontoïd process

Figure 8. Sensor box screwed on C2

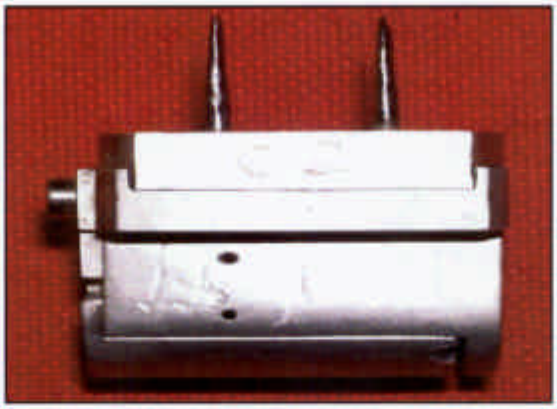

Figure 9. Pins on C2 mounting plate

Since only one screw was used, the box was fitted with two pins which prevented rotation when inserted in the vertebra.

POSITIONING OF THE C5 AND T1 SENSOR BOXES

When the C2 sensor box is fixed, the location of the C5 and T1 sensor boxes are identified by counting the vertebral bodies and the discs to the bottom. The position and axis of the sensors boxes are checked using X-rays. The sensor boxes are gently screwed in position, and the screws axes are checked using X-rays. When all these steps are carried out, another x-ray is taken to verify that the screws are parallel to the vertebra body plane.

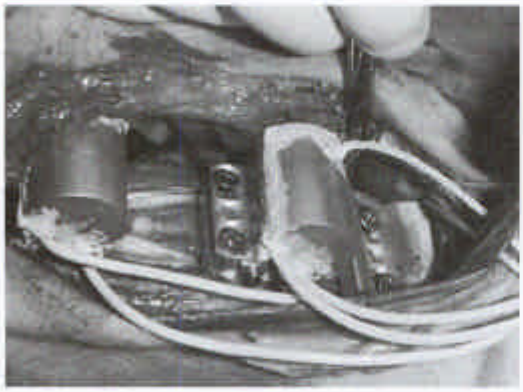

Figure 10. Sensor box screwed on C2

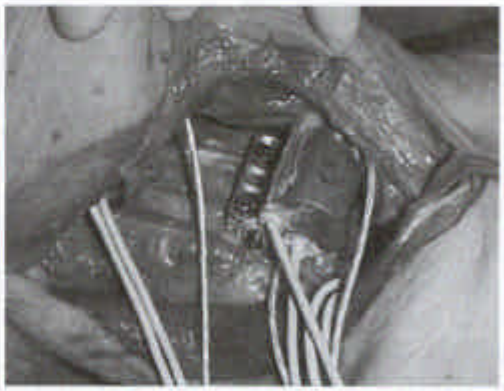

Figure 11. Sensor boxes screwed on C2 and C5

Then the parts of the anterior neck (Esophagus, Larynx, and Trachea) are repositioned on the front of the spine equipped with the sensor boxes. The skin is not stitched because of the volume of the device.

Figure 12. X-ray side view of the cervical spine equipped with three sensor boxes

Figure 13. X-ray side view of the cervical spine equipped with three sensor boxes

X-ray check of the final position of sensors (flexion et extension)

When the three sensor boxes are fixed in position, the compatibility of the sensors boxes (particularly when flexion occurs) is checked using X-rays.

Figure 14. PMHS in position before test with foam in front of the head

RESULTS

When carrying out 19 low-speed, rear-end impact tests on 3 unembalmed cadavers, care was taken to preserve the instrumentation:

1) The sled was equipped with a plate covered with foam to limit the neck flexion when braking. In doing this, no contact occurs between the sensor boxes and the lower vertebra.

2) After each test, the sensor boxes coupling with the vertebrae was checked for any relative motion. The screws were checked as well. That is another reason why the skin was not stitched.

CONCLUSIONS

This methodology allowed data to be obtained without any damage to the mechanical coupling throughout the tests.

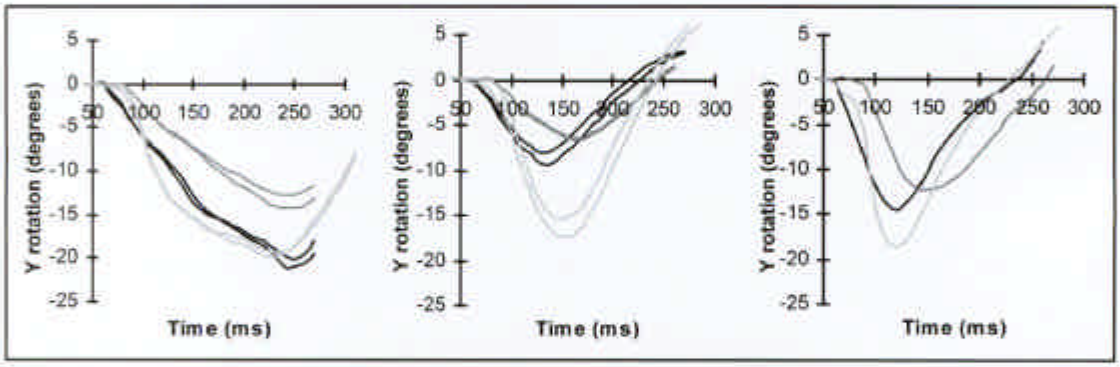

Figure 15. Some curves plotted from data obtained with angular velocity sensors using the methodology described; *PMHS 506,* —*PMHS 507,* —*PMHS 511*

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